

FREEMAN (R.G.)

ON THE

Sterilization of Milk at

Low Temperature

WITH DESCRIPTION OF A NEW AND SIMPLE
APPARATUS APPLYING THE PRINCIPLE
OF PASTEURIZATION

BY

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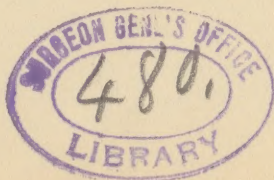
WITH DESCRIPTION OF A NEW AND SIMPLE
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SINCE attention has been directed to the large number of bacteria in the ordinary milk supply, some at least of which appear to be deleterious, efforts have been made to more or less completely kill them by means of heat sterilization. This has, until recently, been accomplished by exposing milk to a temperature of 100° C. (212° F.) for a period varying from twenty minutes to an hour and a quarter. After an experience of six years with milk so prepared, the general verdict of the profession is, I believe, that while sterilized milk is most valuable in the treatment of gastro-intestinal disorders, it is very often unsatisfactory when used as a regular food, seeming for some reason not to fulfil the condition of perfect nutrition. Analyses explain this, in a measure, by showing that various chemical changes take place in milk between 75° C. (167° F.) and 100° C. (212° F.) and that these changes become more marked as the temperature becomes higher. According to Leeds,¹ sterilization at the boiling-point of water or 100° C. (212° F.) causes the following modifications in the milk: The starch liquefying ferment is destroyed and coagulated. A portion of the lactalbumin is coagulated. Caseine is rendered less coagulable by rennet and is acted on slowly and imperfectly by pepsine and pancreatin. Proteid matters attach themselves to fat-globules and probably bring about a less perfect assimilation of fat. Milk-sugar, by prolonged heating, is completely

* Read before the Section of General Medicine of the Academy of Medicine, New York, June 20, 1892.



destroyed. According to Koplik,² "from the temperature of 75° Celsius upward there is a separation of the serum albumin of the milk; the caseine loses its coagulability to rennet, and at 85° C. amounts of rennet, which for the raw condition of milk are found sufficient to act, cease to be effective." Heuppe, quoted by Koplik,² considered that, from a physiological standpoint, milk is best sterilized, if possible, under a temperature of 75° C. In the meantime it has been shown by investigators that temperatures lower than 100° C. (212° F.), if continued for a short time will destroy a very large proportion of the germs, and will destroy with certainty many pathogenic germs which find their way into milk either from the cow or as external contaminations.

The problem then presents itself to devise a method of preparing milk which shall destroy by efficient means the contained germs, and yet in the least possible degree interfere with its nutritive qualities. In other words, the minimum temperature used must be high enough to destroy most of the germs; the maximum must be so low as will not alter materially the chemical composition of the milk. Pasteur³ found in 1868 that exposure of wine for a short time to 55° C. would prevent its spoiling; other observers have found that 60° C. (140° F.) to 70° C. (158° F.) was sufficient to kill bacteria. The term pasteurization is now used for any process by which the germs of wine or milk or other fluid are destroyed by the use of heat between 55° C. and 80° C. followed by rapid cooling. It should be mentioned that pasteurization does not usually render all germ-containing fluids absolutely sterile, all spores are not deprived of life and certain vegetative forms may prove invulnerable. But a sufficient number of such forms may be killed as to check, if not permanently hinder, fermentative changes. The rapid cooling is necessary to prevent the spores which remain in the fluid from developing.

Of the thoroughly known pathogenic germs which may exist in milk, the bacillus tuberculosis, in the light of our present knowledge, is one of the most important. As the result of very elaborate and recent experiments by Yersin,⁴ Granchier and Lidoux-Libard,⁵ and Bitter,⁶ one may conclude that any of the following exposures to heat will destroy the bacillus tuberculosis in milk: 75° C. (167° F.) for ten minutes; 70° C. (158° F.) for fifteen minutes; 68° C. (154½° F.) for thirty minutes.

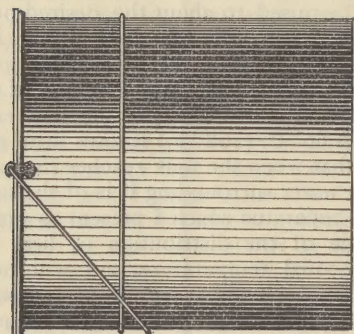
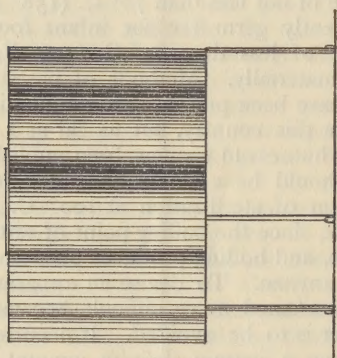
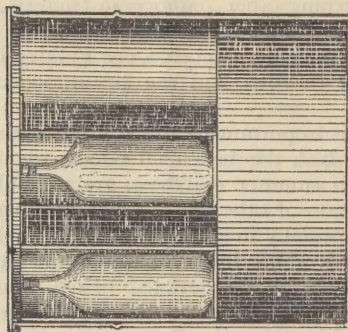
It is practically difficult by microscopic examination, by inoculation experiments, or physical examination of cattle, to determine that the milk of any cow is free from tubercle bacilli. It seems important, therefore, that pasteurization should be carried out with a sufficient tem-

perature to destroy with certainty the bacillus tuberculosis. Concerning other pathogenic bacteria, Van Geuns⁷ found that a few seconds' exposure to 60° C. (140° F.) would kill the cholera sporilla, the Finkler Prior bacillus, the typhoid bacillus, and the pneumococcus of Friedlander.

While it is important to destroy the pathogenic germs above described, the beneficial effects of sterilized milk, especially in summer diarrhoea, are undoubtedly due to the destruction of other, as yet little known forms which the milk, especially in summer, is apt to harbor. Experiments already done in low temperature sterilization of milk and those to be detailed below, would lead us to the belief that these unknown deleterious germs may also be destroyed by this temperature.

From what has been stated one may conclude that a temperature of not less than 70° C. (158° F.) will render milk sufficiently germ-free for infant food, and that a temperature of less than 80° C. (176° F.) will not injure milk materially. Methods of pasteurizing milk in quantities have been presented to the public both in Germany and in this country, but as far as I know no such method for household use has been published. Such an apparatus should be a simple affair for use on a stove. The problem of sterilization at 100° C. (212° F.) was fairly simple, since the boiling-point of water is a definite temperature, and boiling produces phenomena easily recognized by anyone. To devise an apparatus for a lower temperature seemed more difficult, because the use of a thermometer is to be avoided. It occurred to me that by immersing a certain definite amount of milk in a properly proportioned bulk of boiling water, the source of the heat having been removed, the temperature of the milk could be raised to about the desired point, *i.e.*, 75° C. (167° F.). Of course the bulk of the boiling water required depends both on the bulk and the temperature of the milk to be heated. The amount of water in my apparatus is such that in raising the temperature of the milk through 60° C. (108° F.) it loses itself an equivalent of heat, so that when the milk reaches its maximum temperature the water surrounding it is of the same temperature. The apparatus which I present is constructed on this principle of the distribution of heat through two fluids of unequal temperature, and will raise the contained milk through about 60° C. of temperature (from 15° to 75° C.) and keep it at about its maximum temperature for half an hour, after which there is a loss of about one degree every fifteen minutes.

The apparatus consists of two parts, a pail for the water and a receptacle for the bottles of milk. The pail



is a simple tin pail with a cover ; there is a groove extending around the pail to indicate the level to which it is to be filled with water, and supports inside for the receptacle for the bottles of milk to rest on. The receptacle for the bottles of milk consists of a series of hollow zinc cylinders fastened together ; this fits into the pail so that the top of the cylinders are almost level with the top of the pail. I have experimented with other forms of receptacle, including an ordinary tin pail, but find this form the best. Either of two such receptacles may be furnished with the pail, one which will take ten six-ounce bottles, or one for seven eight-ounce bottles.

The apparatus is used in the following way. The pail is filled to the level of the groove with water, covered, and put on the stove to boil, the receptacle for the bottles being left out. Now the bottles of milk are filled and stoppered with cotton, and dropped into their places in the cylinders. Sufficient water is now poured into each cylinder to surround the body of the bottle. This is very necessary for conduction of heat. When the water in the pail boils thoroughly it is taken from the stove and set on a mat or table or other non-conductor, the lid is removed and the receptacle containing the bottles of milk is set inside. The lid is now put on again and the whole is allowed to stand half an hour, after which the bottles of milk are put in a refrigerator. In case there is no refrigerator in the house, measurably the same purpose may be attained by replacing the hot water in the pail by cold water, or, better, ice and water. The water must be renewed at frequent intervals until the bottles of milk are of the same temperature as the water used. Water from the faucet at this season, June, is just 20° C. (68° F.), which is the temperature to which it is desirable to cool the milk as rapidly as possible. When cooled, ice may be put in the water in the pail, the bottles being left in place, or the bottles may be taken out and put in a cool place.

Milk subjected to this process and put immediately into a refrigerator and kept there shows usually no change for several days. A precipitation of caseine takes place in a week or ten days.

I have made careful observations of the temperature of the milk in this apparatus during the various stages of the process, by means of thermometers in the bottles which pass out through holes in the covers. The temperatures I have recorded are the temperatures at the bottom of the bottles, since this part of the milk heats more slowly than the top. The middle bottle does not have exactly the same temperature as the side bottles, but the variation does not exceed two degrees. The accompanying

Table Showing the Rise of Temperature of Milk at the Bottom of the Bottles in the Pasteurizing Apparatus, followed by the Rate of Fall of Temperature in a Refrigerator. Two Separate Experiments.

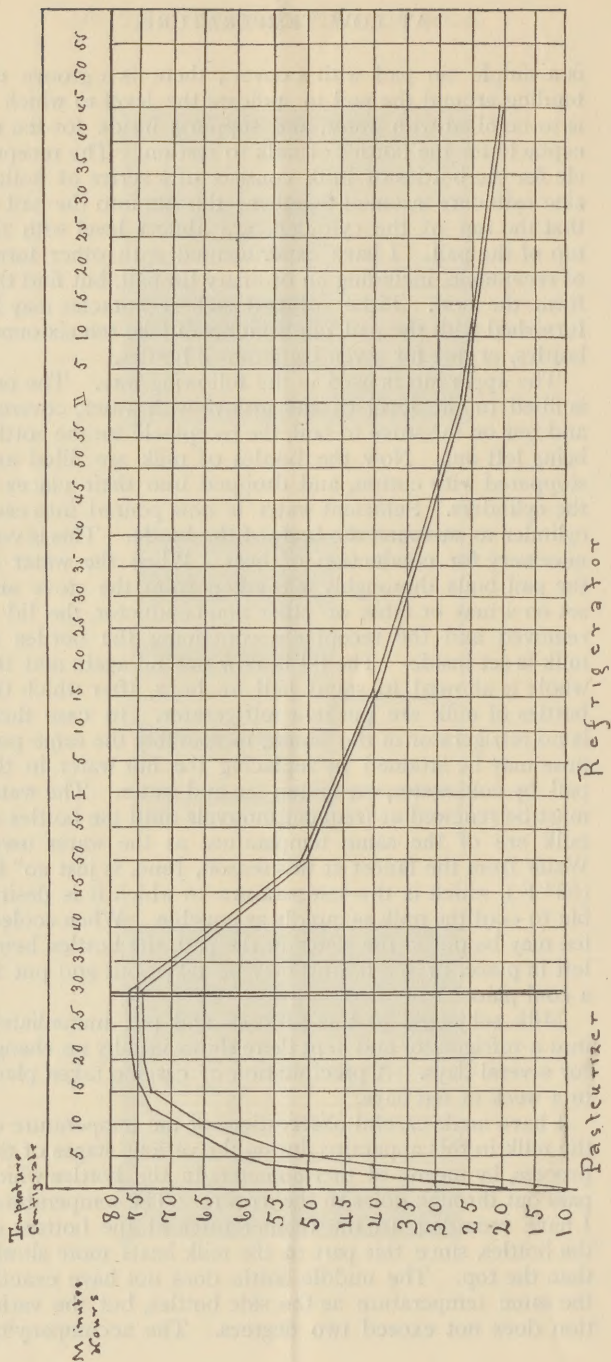


chart shows best the rapidity of the rise of temperature and the constancy of the temperature during the last fifteen or twenty minutes of the half hour exposure. It also shows well that milk at a low temperature is elevated through a greater number of degrees than milk at a higher temperature. This is an important fact and tends to eliminate any error from the uncertainty of the temperature of the milk when put in the apparatus. I have found that the temperature of milk in a refrigerator during warm weather varies from 10° C. to 19° C. (50° F. to 64° F.), but is usually between 13° C. and 16° C. (55° F. to 61° F.). Such milk would reach about 75° C. (167° F.) in this apparatus. Referring to the chart, we see that the temperature rises through 40° to 45° C. (72° to 79° F.) in the first five minutes, and that a temperature of 70° C. (158° F.) is reached in eight to ten minutes, depending on the temperature of the milk introduced. In leaving the milk in this apparatus half an hour we expose it to a temperature of over 70° C. (158° F.) for twenty minutes. The cooling in the refrigerator is slow. It requires two hours and fifteen minutes to reach 20° C.

Table Showing the Number of Bacteria in 1 c.c. of Milk Before and After Pasteurization for One-half Hour.

Number of Experiment.	Number of Bacteria in Raw Milk.	Days of Exposure of Pasteurized Milk.			
		1	2	3	4
I.....	8,960	0	0	0	0
II.....	90,000	0	0	0	0
III.....	28,288	0	0	0	—
IV.....	Innumerable	0	—	—	—
V.....	18,432	0	0	0	—
VI.....	Innumerable	0	0	0	—
VII.....	230,400	0	0	1	—
VIII.....	100,000	0	0	1	—
IX.....	17,384	0	0	—	—
X.....	Innumerable	0	1	—	—
XI.....	54,900	0	—	—	—
XII.....	60,230	0	—	—	—
XIII.....	Innumerable	0	—	—	—

I have made a series of experiments at the Bacteriological Laboratory of the College of Physicians and Surgeons to test the efficiency of this apparatus in the pasteurization of milk. Specimens of milk obtained at different times and from different sources have been examined to determine the number of bacteria contained in one cubic centimetre before and after pasteurization. This was accomplished by planting in gelatine plates. The result of this work is given in the accompanying table from which it may be seen that while the raw milk used con-

tained from 8,000 to 230,000 and more bacteria to each cubic centimetre, the same milk after pasteurization usually contained none.

Summary.—1. Both clinical and chemical evidence lead us to believe that milk is injured for infant food by the formerly practised methods of sterilization by boiling or steaming, or even by any temperature above 80°C . (176°F .).

2. Pasteurization with a temperature between 70°C . and 80°C . (158°F . to 176°F .) destroys tubercle bacilli, and, according to Van Geuns, destroys also the typhoid bacillus, the cholera bacillus, and the pneumococcus of Friedlander, also most of the ordinary milk-germs, and does not injure milk.

3. Milk may be pasteurized by simply immersing it in a proper proportion of boiling water, the source of heat having been removed, and leaving it so immersed for half an hour.

4. In the apparatus here described the proper proportion between the boiling water and the milk has been calculated and tested, and by the use of the apparatus in practice ordinary milk in summer is found to have been rendered practically sterile, and keeps unchanged in a refrigerator for several days.

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